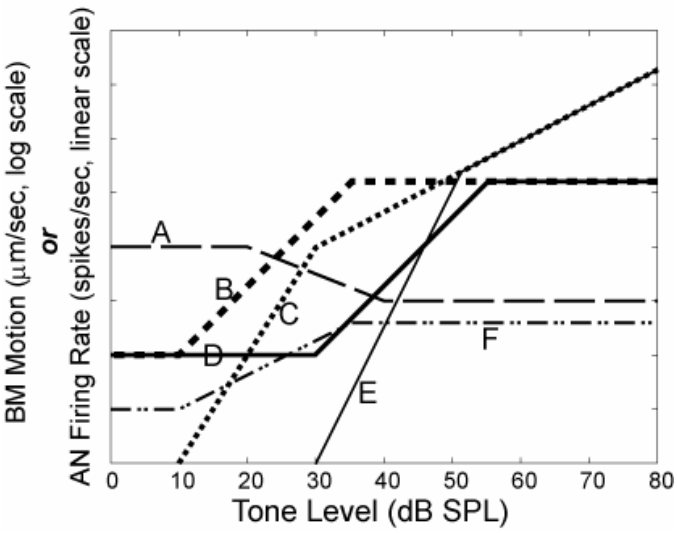
HST.723 Final Exam
May 21, 2007

1. **Answer each of the 11 questions on a separate sheet of paper. You are encouraged to use these pages.**
2. **Write your name and Question # on every page you turn in. The pages will be split between instructors for grading.**
3. **All questions will be weighted equally.**

Name: _____ **Question 1**

An experimenter developed a preparation in which basilar membrane (BM) motion can be measured simultaneously with recordings from single auditory-nerve (AN) fibers. In one experiment, data were obtained for several conditions, three of which are listed below. In her excitement, the experimenter plotted some of the data all on the same graph (shown below). A pair of plots (BM and AN) is included for each of the three conditions listed below, ***but other plots may have also been included and some conditions may produce identical plots.*** For each of the three conditions, identify which curve shows the BM data and corresponding AN data, and for each, state the key features of the curve that led to your identification. All of the AN plots are on the same vertical scale and all of the BM plots are on the same vertical scale (but different from the AN scale). The BM motion includes only the Fourier component at CF. To produce the tone level functions, 25 ms tone bursts were used, repeated 5 times per second.



Condition 1: A tone level function at CF, no other stimulus.

BM plot: ____, Reason:

AN plot: ____, Reason:

Condition 2: A tone level function at CF, with the tone preceded by a 100 ms, 20 dB SPL tone burst at CF that ended 5 ms before the CF tone began.

BM plot: ____, Reason:

AN plot: ____, Reason:

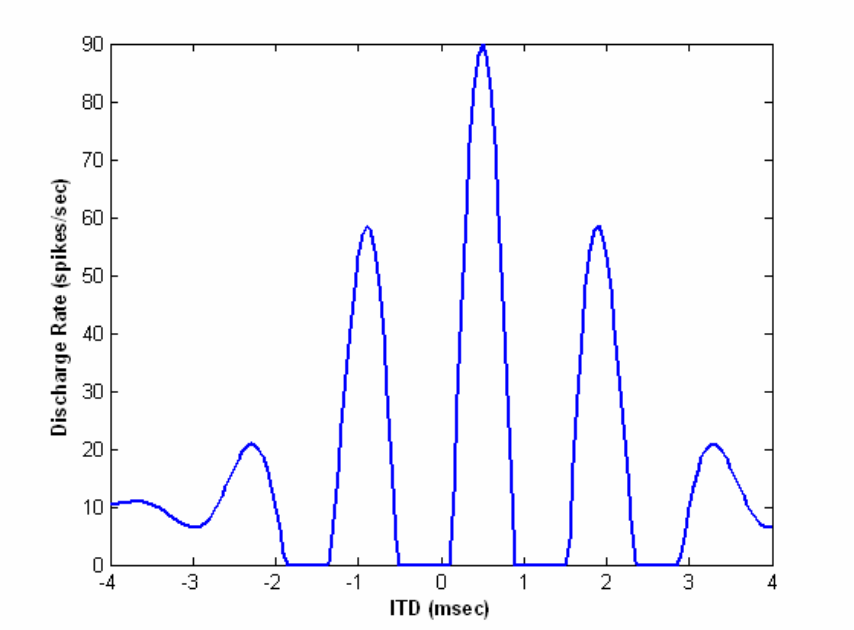
Condition 3: A tone level function at CF, with a simultaneous tone burst at a frequency of CF/3 and at 75 dB SPL.

BM plot: ____, Reason:

AN plot: ____, Reason:

Name: _____ **Question 2**

The figure below shows the average firing rate of a medial superior olivary (MSO) neuron as a function of interaural time differences (ITD) of a stimulus. Positive ITDs mean stimuli leading at the right ear.



a) Is the stimulus more likely to be a pure tone or broadband noise? Explain.

b) What is the neuron's best frequency?

c) Is this neuron more likely to be located in the left MSO or the right MSO? Explain.

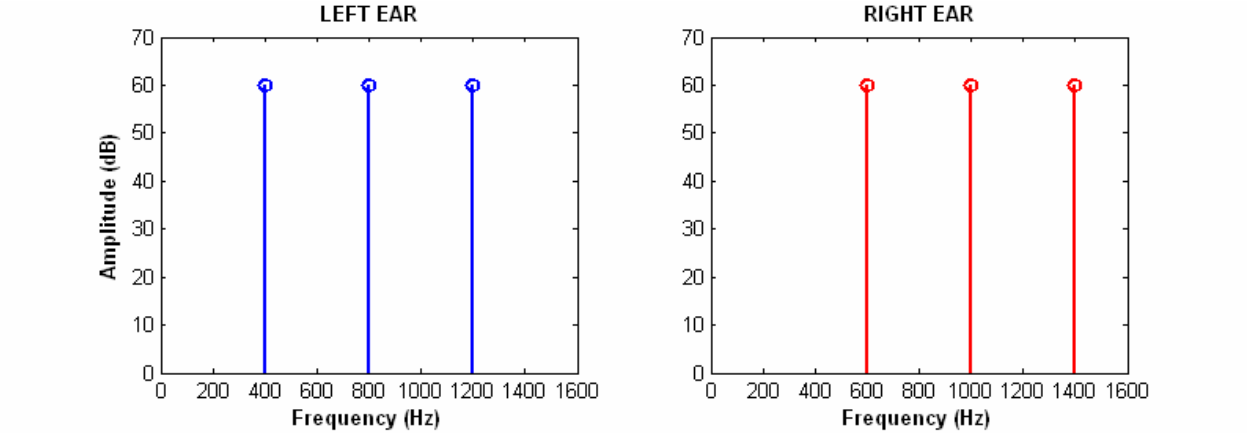
d) If the neuron's best ITD was created entirely by disparities in the cochlear places of innervation of the inputs from the two ears, which input (left-ear or right-ear) would have the higher characteristic frequency.

e) Aspirin can cause a transient dysfunction of outer hair cells, resulting in wider bandwidths of cochlear tuning. How would the rate-ITD curve of this neuron change following aspirin administration? Assume the effects of aspirin are the same in both ears.

Name: _____ **Question 3**

The pitch of missing-fundamental stimuli can be heard even if different, non-overlapping sets of harmonics are presented to opposite ears. In general, **the pitch heard for such dichotic presentation is the same as if both sets of harmonics were monaurally presented to either ear.**

Consider the example below, where 3 partials are presented to the left ear, and a different set of 3 partials are presented to the right ear.



a) What pitch would be heard for monaural presentation of the stimulus in the **left** ear? Circle one and explain: **200 Hz** **333 Hz** **400 Hz** **500 Hz** **600 Hz**

b) What pitch(es) would be heard for monaural presentation of the stimulus in the **right** ear? Circle **one or two** and explain:
200 Hz **333 Hz** **400 Hz** **500 Hz** **600 Hz**

c) What pitch would be heard for **dichotic** presentation of the two stimuli? Circle one and explain: **200 Hz** **333 Hz** **400 Hz** **500 Hz** **600 Hz**

d) The Shamma and Klein (2000) paper discussed in class shows how harmonic templates could arise via a matrix of coincidence detectors, and once formed, how this template matrix could extract pitch. The cochlear nucleus is proposed as a possible anatomical site for the coincidence matrix. Do the above results support this anatomical location? If not, suggest another site (e.g. medial superior olive, primary auditory cortex, …) that would be more consistent with known anatomy, physiology and psychophysics. Explain your reasoning.

Name: _____ **Question 4**

Your first job is to watch over cochlear implant patients (N=2) in Nome, Alaska. The job is very boring until an extraterrestrial walks in and asks you to improve his cochlear implant systems. His auditory system includes three ear canals, three middle ears and three cochleae. Two of these ears (A and B) are located on either side of the head (like ours) and the other (C) is in the middle of the forehead. All three cochleae are implanted and each implant has a sound processor. Making measurements on the three sound processors, you deduce that cochleae A and B are customized to process only ITD information, while cochlea C's focus is speech reception. CT scans show cochleae of size similar to humans that are each implanted with an array of 60 electrodes.

a) Sound processors A and B each drive only one electrode of their respective array (A the most basal electrode, and B the most apical) with a single, biphasic current pulse generated once every second with an ITD based on the sound input. How would you change the processing of A and B to improve the extraterrestrial's ITD sensitivity and why? You can implement any stimulation scheme you want (up to 60 channels). Assume everything you know about the human auditory system and human cochlear implants applies here. Limit your answer to 4 sentences or less.

b) Processor C is designed like a conventional earth-style sound processor but with only four spectral channels connected to the four most basal electrodes. How would you change this processor to provide better speech reception in quiet and in noise? Again, there are no constraints on the stimulation strategy. Limit your answer to 4 sentences or less.

Name: _____ **Question 5**

Figure 1 schematizes the organization of auditory cortex in Macaque. Figure 2 shows a human superior temporal lobe viewed from above.

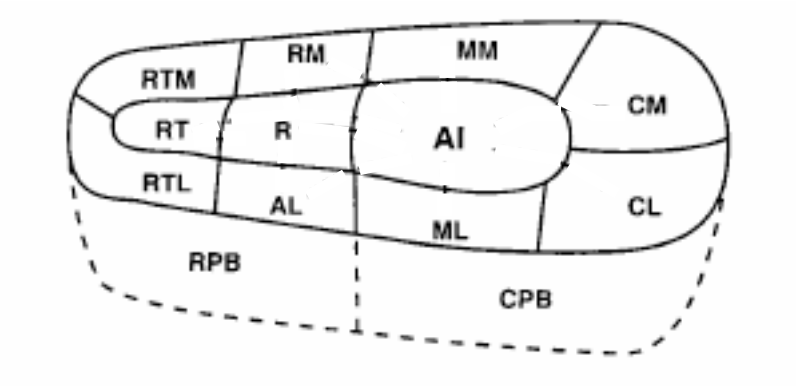


Figure 1

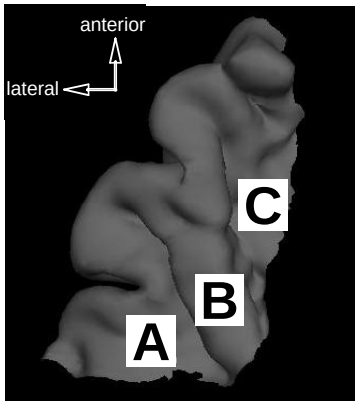


Figure 2

a) Which labeled areas in Figure 1 comprise the core region of auditory cortex?

b) Indicate the tonotopic organization of these regions directly on the figure.

c) Which region of auditory cortex receives the highest density of direct projections from the ventral division of the medial geniculate body?
(1) core (2) belt (3) parabelt

d) Which layer within the cortical gray matter is the main recipient of these projections?
(1) layer II (2) layer X (3) layer IV

e) Human primary auditory cortex mainly overlaps which structure in Figure 2 (A, B, or C)?

f) Assign names to the structures labeled in Figure 2:

A _____

B_____

C_____

Name: _____ **Question 6**

For each of the following, circle **T** if the statement is TRUE, and **F** if the statement is FALSE. If the statement is False, give a reason why it is false. (READ CAREFULLY!).

a) In psychophysical tests, for high-side maskers, forward maskers produce more masking than simultaneous maskers.
T **F**, reason:

b) In psychophysical tests, suppressive unmasking can occur in simultaneous masking but not with forward masking.
T **F**, reason:

c) In psychophysical tests, notched noise is used as a forward masker because it reduces off-frequency listening, but this is no longer true when notched noise is used as a simultaneous masker because of the suppression produced with simultaneous masking.
T **F**, reason:

d) The growth of basilar-membrane motion is highly compressive for CF tones but linear for below-CF tones; therefore when a below-CF tone is used to mask a CF tone the growth of masking is greater than 1dB/dB.
T **F**, reason:

e) In low-side suppression with a suppressor much lower in frequency than the probe tone, if suppression is seen twice a suppressor cycle, this indicates that at-rest, the OHC stereocilia transduction point was at the exact center of a symmetric current-versus-angle transduction function.
T **F**, reason:

Name: _____ **Question 7**

Bandpass noise stimuli are presented through headphones in a virtual acoustic environment that accurately reproduces the spatial cues available to human listeners in free field. In some conditions, the normal spatial cues are altered by imposing an ITD bias to the stimulus. Positive ITDs and azimuths refer to sound sources located on the right.

a) A lowpass noise (0.5-2 kHz) with spatial cues for +30º azimuth in the horizontal plane is presented with an ITD bias of –600 μsec. What is the perceived lateral angle of the stimulus? Give the average answer across a group of listeners.

b) Now, a highpass noise (4-16 kHz) is presented with the same azimuth and ITD bias as in (a). What is the perceived lateral angle of the stimulus?

c) How would your answer in (b) change if the noise was 100% amplitude modulated with a 100-Hz square wave? Specifically, would the perceived source location move to the left, to the right, or stay the same?

d) How would your answer in (a) change if the experiment were repeated in cats trained to saccade to the location of a sound source. Assume the directional cues in the stimulus are appropriate for +30º azimuth in cats, but the ITD bias remains –600 μsec. What would be the final lateral angle of the saccade? Assume the cats can accurately saccade to any direction.

Name: _____ **Question 8**

Single-unit recording and fMRI are two techniques that have been used to explore the responses of primary auditory cortex. However, these techniques might not always demonstrate similar results.

a) For example, tonotopic organization has been the subject of much investigation. Describe how single-unit recordings are used to demonstrate tonotopic organization in the primary auditory cortex. Then describe how tonotopic organization might be explored using fMRI. Specify the stimulus conditions used for each technique. Discuss any expected differences in the two measures of tonotopy.

b) Describe another example of an experimental situation discussed in class in which single-unit recording and fMRI measures give different results. Please state a different electrophysiologic measure that is more in agreement with fMRI results in this situation.

Name: _____ **Question 9**

In an fMRI experiment on human listeners, you discover that iterated ripple noise produces greater activation than broadband noise in a circumscribed region of auditory cortex ("Region X"). You hypothesize that Region X may be specifically involved in coding the pitch of sound. Describe two strong tests of this hypothesis. Clearly state the purpose of each test. Limit your description of each test to four sentences or less.

Name: _____ **Question 10**

a) Mistuning a harmonic near a formant can change the perceived identity of the vowel

TRUE FALSE

b) Concurrent vowels can be identified at above chance levels even with no difference in F0

TRUE FALSE

c) A harmonic naturally segregates from a vowel if it differs in ITD from the other harmonics

TRUE FALSE

d) Coherent frequency modulation is a strong cue for simultaneous grouping for inharmonic sounds

TRUE FALSE

e) Tones of alternating frequencies (such as in the ABA_ paradigm) are more likely to be heard as two streams at slower rates of presentation

TRUE FALSE

f) Sequential streaming based on F0 is possible with only unresolved harmonics

TRUE FALSE

g) There is evidence that attention is required for the build up of streaming

TRUE FALSE

Name: _____ **Question 11**

An electrode records from the cochlear nucleus of a cat. The electrode recorded units at sites 1, 2, 3, and 4, on two separate electrode tracks (A and B) illustrated on the next page. On the chart below, fill in the data most likely to be obtained from those recording sites. Under the heading Most common single unit type, choose one answer from the following list: **"Primarylike", "Pri-Notch", "Onset", "Chopper", or "Pauser".**

Site	approx CF (kHz)	Pre-potential size (none or large)	Most common single unit type (see list above)	Cell type corresponding to single unit type (Nissl classification)
1				
2				
3				
4				